GeoClutter Seabed Reflection and Scattering Measurements

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LONG TERM GOALS

The long term goal is to improve performance of low-mid frequency active sonar systems operating in littoral regions. One of the most serious problems for employment of active sonars is the overwhelming number of clutter events, many of which come from geologic features on and in the seabed.

OBJECTIVES

The objectives of the three-year effort are to identify the geologic features and the associated physical mechanisms that lead to geologic clutter in littoral environments and obtain the physical descriptors of the seabed environment (geoacoustic properties) required for physics-based modeling.

APPROACH

The overall approach attempts to first localize the clutter, then identify the mechanism (in practise often done by correlating the clutter location with surveyed seabed or other oceanographic features), and finally measure high-resolution geoacoustic properties at and near the clutter location (as required for phsyics-based modeling). A self-consistent approach is being forged, wherein the geoacoustic basis of the reflection and scattering data are treated in a unified fashion. The approach for FY03 included analysis, modeling and experimental work.

WORK COMPLETED

Measurements were conducted during GeoClutter Acoustics Experiment03 on the New Jersey shelf (STRATAFORM) to determine meso-scale geoacoustic properties, crucial for future modeling studies for predicting long-range reverberation and clutter characteristics. A broadband seismic source (Uniboom) was employed in conjunction with the Five-Octave-Research Array (FORA). Both were towed from the R/V Endeavor along tracks where clutter had been observed in the GeoClutter 2001 experiment.

Seabed scattering data from GeoClutter and Boundary Characterization Experiments have been analyzed to determine clutter mechanisms. In addition, planning efforts are well underway for the Boundary04 experiment in the Straits of Sicily in the spring of 2004 in conjunction with the SACLANT Undersea Research Centre. One of the goals of the experiment is to identify the specific

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14. ABSTRACT
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mechanism involved in observed clutter from mud volcanoes. Measurements of gas concentrations in the water column and sediment in association with short-range backscatter measurements, will help identify the roles of scattering from the gassy sediment, the water column plume and the mud volcano itself.

RESULTS

Our analysis of the reverberation and geophysical data indicate that some (perhaps many) of the geoclutter features on the flat-lying portion of the Malta Plateau are caused by out-gassing of the earth (presumably primarily methane). Submarine mud volcanoes, discovered in this area during the Boundary2002 experiment (see [1]) occur at numerous locations on the plateau. They are observed both at the seafloor boundary where they emit gases, water, and sediments, as well as buried meters or up to hundreds of meters below the seabed. It appears that both the buried and the proud mud volcanoes produce clutter.

Figure 1 shows broadband reverberation (100-1800 Hz) from Sound Undersea Signal (SUS) charges and a 128 element towed array with Hanning shaded beams. The data have a time variable gain correction to aid in visualization of clutter events far from the source; the units are relative decibels. The left-right ambiguity from the array is clearly seen, the array heading is roughly west northwest. Resolving the ambiguity was performed by measuring reverberation at a variety of positions and array headings. The highest return in Figure 1 is from a nearby tanker (the noise from the tanker is visible along the entire radial). Also visible are returns that correspond to the position of 2 mud volcanoes. The southernmost mud volcano is actually buried approximately 3m sub-bottom (see Figure 2, features at a ~4 km) and the seismic reflection data show a cluster of volcanoes which is frequently observed on the shelf. It is possible that proud mud volcanoes are part of the cluster but were not imaged in the profile. It is very reasonable, however, to expect to sub-bottom features to be easily imaged across the entire frequency band since the sediments above the mud volcanoes are nearly acoustically transparent (0.98 sound speed ratio, 1.3 density ratio, and of order 0.01dB/m/kHz attenuation (see [2-3]).

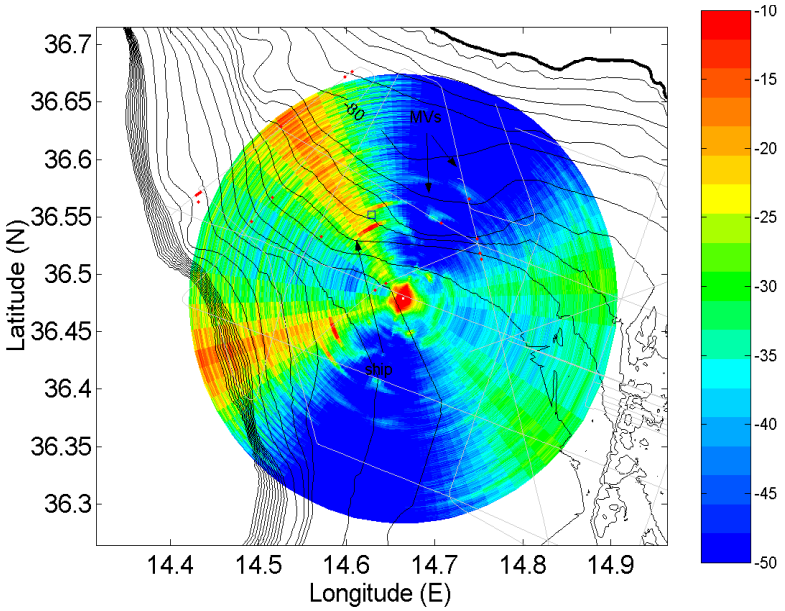

Figure 1. Broadband reverberation (relative dB) from SUS in the Straits of Sicily. The island of Sicily is in the upper right hand corner. The data have a time variable gain. There is a left-right ambiguity in the figure around the axis of the towed array. The strong radial line to the northwest is from a ship (tanker) tending the Campo Vega oil rig (box). The reverberation return from two mud volcanoes (MVs) are indicated by the arrows. The gray lines are seismic reflection survey tracks.

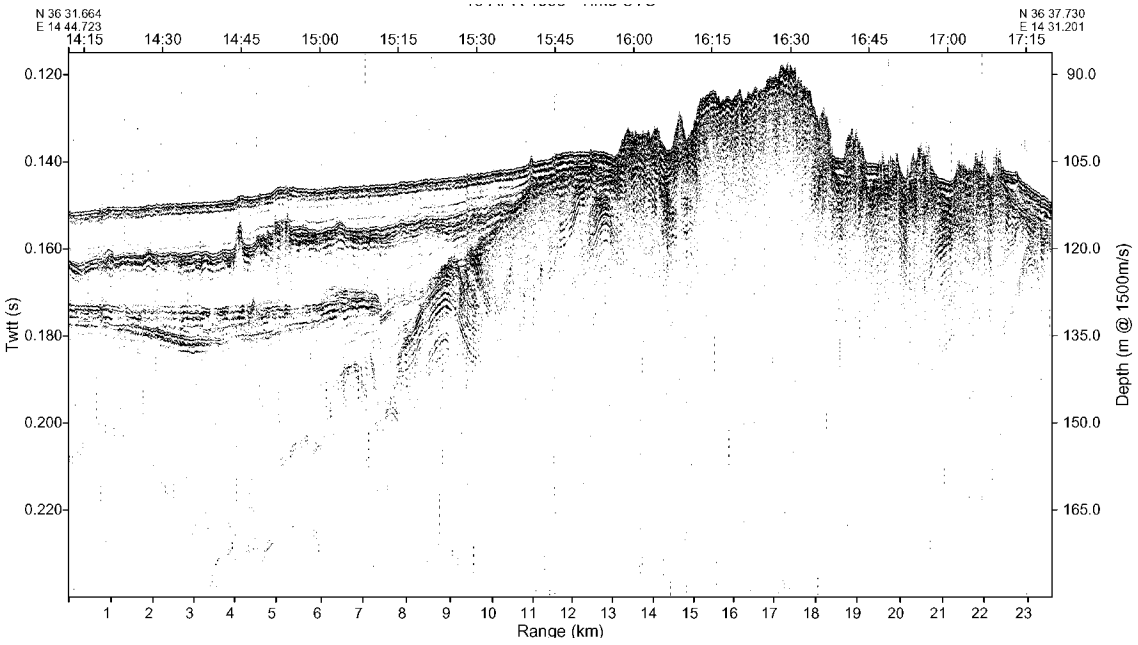

Figure 2. Seismic reflection data along a west-northwest track showing the mud volcanoes at 4 km corresponding to the southernmost MVs shown in Figure 1. Start and end positions are given in the upper margin. Diffuse reverberation from the ridge (at ~13-20 km) would have been observed at a position~36.6ºN 14.6ºE but it is masked by tanker noise.

There are some gas-related features that may not be related to mud volcanism. Figure 3a shows another reverberation measurement nearer to the Ragusa ridge, which is the largest bathymetric feature on the shelf. There is broad reverberation return all along the ridge, and then discrete clutter events on the flat-lying sediments. Our geophysical measurements (Fig 3b) show that the southernmost clutter event is due to sediment out-gassing. It is probable that in this instance, the dominant clutter mechanism is due to the gaseous plume rather than the gas that clearly exists in the seabed itself.

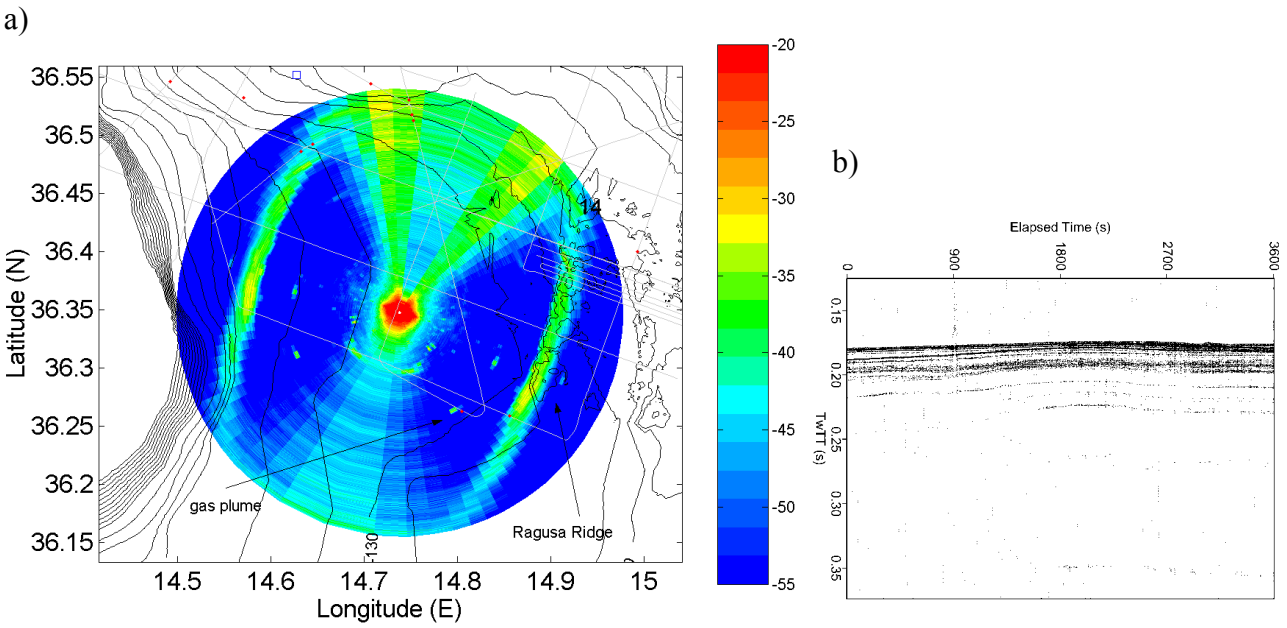

Figure 3. a) Broadband (SUS) reverberation in the Straits of Sicily. The strongest return is from the Ragusa ridge. The reverberation return from a gas plume is indicated by the arrow. b) seismic reflection data over the gas plume (at 900 seconds elapsed time), the water sediment interface is at ~0.18 seconds two-way travel time (TWTT); the plume is ~75m in diameter. It is not clear whether the plume is associated with a mud volcano. Other clutter events can also be seen in the figure – their origin is not yet known.

IMPACT/APPLICATIONS

The discovery of submarine mud volcanoes in the shallow water portion of the Straits of Sicily is stimulating to the underwater acoustics and geology/geophysics communities. The importance for active sonar is that these features give rise to false alarms. An interdisciplinary team is being formed to address questions that challenge current assumptions and hypotheses about the Malta Plateau region. The team will attempt to obtain sediment entrained gas and expulsed gas estimates as well as to determine the geographic extent, both locally and globally of the mud volcanoes. There are indications that a large number of (as yet uncharted) submarine mud volcanoes exist [4]; thus, understanding characteristics of these mud volcanoes may enhance our ability to predict areas in which they are likely to exist. The biology community is also interested in the mud volcanoes since new life forms are sometimes found in such extreme environments.

RELATED PROJECTS

ONR Uncertainty DRI: Collaborating on marine geologic, geophysical, and geoacoustic data in the New Jersey STRATAFORM area as well as tools to define the uncertainty of these data.

Boundary Characterization Joint Research Project ONR-NATO SACLANT Centre: Providing geologic, geophysical, geoacoustic and acoustic data in the Straits of Sicily.

European Union GEOSTAR Project, collaborating on approaches for geochemical measurements of gas flux from the mud volcanoes.

ONR SWAT Program: Collaborating on geoacoustic inversion results in the New Jersey STRATAFORM area.

EA-89 Program – I supplied seabed scattering and reflection loss to the program in order to help validate their long-range reverberation parameter estimates.

Continued contact with a signal processing research (Bill Comeau, NUWC) who has also observed significant clutter on the Malta Plateau during the SWAC trials in the early to mid 90s' to assess how much clutter their system suffered may have come from mud volcanoes.

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